

**Conclusions:** We report here for the first time measurements of DNA damage with pulsed protons at ultrahigh dose rate ( $10^9$ - $10^{10}$  Gy/s) under hypoxic conditions.

**Key words:** 53BP1, HIF-1 alpha,

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**Faster QA through improved proton calorimetry. Another spin-off from particle physics**

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We have used the calorimeter module originally designed for the SuperNEMO experiment to measure the energies of protons at the Clatterbridge proton therapy cyclotron.

Such measurements are necessary for time consuming QA checks, and by improving the rates and energy resolution this time can be considerably reduced.

Preliminary results show that an energy resolution of sigma 0.7% can be achieved for low rates which will later be compared to the high rate data. We hope to extend this technique to proton radiography as well.

**Keywords:** proton therapy, radiography, scintillator

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**Study of Dosimetric Characteristics of a commercial OSLD system**

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**Introduction:** Cancer treatment by radiotherapy is a complex process and needs accurate radiation treatment delivery and can be verified using in vivo measurements. Optically stimulated luminescence dosimeter [OSLD] has been used extensively for beam dosimetry, radiation protection including in vivo measurements due to their simple readout process and multiple times readout facility.

**Aim and Objective:** The aim of the present work is to study the dosimetric characteristics of commercial OSL system by Landauer Inc. before using it for clinical practice in radiotherapy.

**Material and Methods:** The OSLD system used is a commercial InLight™ microstar reader system, manufactured by Landauer Inc. The detector consist of Al<sub>2</sub>O<sub>3</sub>:C nanodot as OSL material, enveloped in special light protective plastic holders. In the present study the irradiations are carried out in 30\*30 cm<sup>2</sup> solid water slab phantoms. Bhabhatron - II cobalt 60 telecobalt radiation is used for most of the measurements carried out. Clinac - iX is also used for 6 MV and 10MV energy photon beams to study dose rate and energy dependence. Absolute dose is measured using a 30013 PTW ionization chamber in solid water and compared with OSL dosimeter measurements.

Unless otherwise mentioned, all irradiations carried out using an SSD setup (80cm for co-60 and 100cm for linac) with 10\*10cm<sup>2</sup> field size. OSL response with given dose is investigated for doses ranging from 0.5 to 4Gy. Energy dependence of OSL is investigated for Co-60, 6MV, 10MV beams, delivering a dose of 50 cGy each. Further the dose rate dependence of OSL detector is evaluated for dose rates of 200, 400, 600 cGy/min in accelerator with 6MV energy beam. We also studied the field size dependence by irradiating OSLD chips to 50 cGy dose for various field sizes ranging from 4\*4 to 35\*35 cm<sup>2</sup> for cobalt -60 beam. The dosimeter angular response is studied at various gantry angles from 90° to 270°, at an interval of 30°, with and without build up respectively.

**Results:** In present study it was observed that the OSL dose deviation is about - 4.5% as compared with ionization chamber. Further the reproducibility of detector is found to be within 3.44% standard deviation, with COV 0.035. There is no significant energy dependence of Al<sub>2</sub>O<sub>3</sub>:C detector for the energy range Co-60 to 10MV. The detector response was found to be linear in the dose range of 0.5 to 4Gy. The

detector response is almost independent in clinical dose rate range, nearly independent of field size and is independent to angle of incidence of beam.

**Discussion:** The dosimetric characteristics of OSL system were studied and found that OSL response is energy and dose rate independent. The stability of system and linear dose response relationship makes it a good dosimeter for in vivo dosimetry in clinical radiotherapy.

**Keywords:** OSLD, invivo dosimetry, radiotherapy

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**Simulation of recombination in an air filled ionization chamber**

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**Background:** Air filled ionization chambers are the dosimeters of choice for photon therapy as well as particle therapy. Dosimetry protocols for ion beams take recombination effects into account, where the generated charge in the ionization chamber may recombine before it is picked up by the electrode. It is well established that intra-track recombination (initial recombination) is negligible in medical photon and electron beams, but must be accounted for in beams with heavy ions. However, the underlying assumptions for establishing the recommended method for correction for inter-track recombination (general recombination) still remains unclear today [1]. The current two-voltage method only is applicable for low LET-beams, with no initial recombination present [2,3], and this progress report focuses on a detailed recombination study of ion beams.

Here, we calculate the columnar recombination when the ion track is

- parallel to the electric field
- rotated with an angle between 0 and  $\pi/2$  relative to the external field which was estimated analytically by Jaffé [4] and later confirmed experimentally by Kanai et al [5].

The general recombination is investigated by

- sampling two parallel ion tracks at different separation and initialized at different times
- comparing the simulation of a continuous beam with Greening's formula [6] for collection efficiency.

Simulations are confirmed by comparison with experimental data.

**Methods:** We have investigated positive and negative charge carrier distributions (CCDs) by solving the differential equation using a finite difference approach,

$$\frac{\partial n_{\pm}}{\partial t} = -D_{\pm} \nabla^2 n_{\pm} \mp \vec{\nabla} \cdot (\mu_{\pm} \vec{E} n_{\pm}) - \alpha n_+ n_-$$

with derived from the initial CCDs, the diffusion

constant, the mobility, for positive and negative CCDs,

$\vec{E}$  the electric field vector, and the recombination constant.

**Results:** Our simulations reproduced the analytical solution from Jaffé and the experimental results by Kanai et al. On this platform we could also verify the Greening analytical solution.

**Conclusion:** The simulations of pulsed and continuous beams are seen to agree well with the known theories and experimental data, and the program is thus capable of reproducing the initial and general recombination processes taking place in high LET-beams. This allows a deeper study of the actual recombination processes taking place when several ion tracks are present and ultimately account for the overall recombination in air filled ionization chambers irradiated with high LET-beams.

**Keywords:** ionization chambers, recombination, high LET